matrix an expression he calls its determinoid. This is, in fact, a sum of maximum determinants, taken from the matrix, with a rule of sign for each. There can be no doubt of the value of the theory of matrices, and that a good book on the subject is a desideratum. Whether the notion of a determinoid is likely to be anything like so valuable is a doubtful question, and we confess that we would rather have had a treatise on matrices alone. The present volume ends with a chapter on the solution of any system of linear equations, and to read this first of all is perhaps the best way to become favourably impressed by the treatise. The earlier chapters seem rather diffuse, and contain a large number of new technical terms, some of which, like "corranged," are not at all attractive. The next volume will contain applications to algebra and geometry, besides a discussion of matrix equations of the second degree. When this appears it will be easier to form a judgment on the work as a whole; meanwhile, we can see that it contains a great deal of valuable matter expressed in one consistent notation.

G. B. M.

OUR BOOKSHELF.

Brands Used by the Chief Camel-owning Tribes of Kordofan. (A Supplement to "The Tribes of Northern and Central Kordofan.") By H. A. MacMichael. Pp. viii+40+xvii plates. (Cambridge University Press, 1913.) Price 6*s*. net.

NEARLY thirty years ago Robertson Smith lamented that no good collection of *wasm* (the tribal marks with which every Arab tribe brands its cattle) had been made, and now Mr. MacMichael has published as a pendant to his history of the Arab tribes of Kordofan a collection of the marks used by these tribes as camel brands. The utility of such a work to the members of the Sudan Civil Service is too obvious to need accentuation, but there is also a good deal of scientific interest attaching to it, although the writer's experience in the Sudan makes him regard it as improbable that the high hopes cherished by Robertson Smith will be realised, that such collections will enable us to trace the ancient history of the people.

No doubt each tribe, or each section of a nomad tribe, once had a distinctive brand, but it seems that in many cases this has been lost, or at least has fallen into disuse. The brands themselves are for the most part named after common objects, such as *bersham*, the "cross-hilt of a sword," and *bab*, "a door," while others derive their names from the part of the camel which is branded; thus, *bakkai*, derived from the word meaning "to weep," is applied to a linear vertical mark below the eye, because it is here that tears trickle down. Generally the brand is highly conventional and unlike the object it represents, but in a few cases, though simplified, it retains all the essentials of the original, as, *e.g.*, the *rigl el ghorab*, a "crow's-foot," used by some of the negroid "Arabs" of the northern hills.

Rainfall Reservoirs and Water Supply. By Sir A. R. Binnie. Pp. xi+157. (London: Constable and Co., Ltd., 1913.) Price 8*s*. 6*d*. net.

IN the application of exact meteorological observations to practical life, the utilisation of rainfall records by the waterworks engineer takes a foremost place. Rainfall is moreover among the most important of the natural resources of a country, and it is fitting that Sir Alexander Binnie should put together the results of his wide experience in a book which will impress the townsman with this fact in its more direct association with his daily life, in addition to giving to the engineer a survey of the problem with which he is faced, and of the methods of dealing with it.

The first chapter treats of the measurement of rainfall and the variation in amount from year to year and place to place; diagrams are given to show how the total fall increases as the ground rises, and emphasis is laid upon the fact that in a region with a prevailing wind direction the maximum rainfall frequently occurs on the lee side of the high ground. Another diagram illustrates the approach of the average annual rainfall to a normal value as the number of years increases; thus one year may be 50 per cent. above or 40 per cent. below the normal, but the average of ten years is not likely to differ by more than 10 per cent. in either direction from the normal value.

The next chapter deals with the flow from the ground, floods, and evaporation, about which our knowledge is very deficient owing to the scarcity of trustworthy records. Subsequent chapters are devoted to the methods of calculating the available supply, the construction of reservoirs, and the arrangements for conveying the water from the source and distributing it to the users. There is much that is technical naturally in these chapters, but the subject is treated in such a way that even the details are made interesting, and their importance for safety or economy is clearly shown.

E. G.

Planetologia. By Ingegnere Emilio Cortese. Pp. vii+387. (Milan: Ulrico Hoepli, 1913.) Price 3 lire.

IN view of the fact that nearly 300 pages are taken up with terrestrial phenomena, and only eighty pages are devoted to the remaining members of the solar system, the title "Planetologia" scarcely seems suitable for the present book. Perhaps the author could not think of a more suitable title.

The book contains an exposition of some of the main physical properties of the earth's crust, the age of the earth, its past geological history, the theories of tides, earthquakes, volcanoes, the origin of the earth's atmosphere, and the principal

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physical features of the planets and moon. As a geologist the author claims to have formed definite views of his own on these questions, differing in many respects from commonly accepted theories; but, as he points out, it would be impossible for a writer to substantiate these varied theories unless he had travelled all over the world, besides being, at the same time, a mathematician, a physicist, a chemist, an astronomer, and a geologist. Considerable attention is given to theories of the displacement of the earth's axis.

A collection of theories of this kind, if thus propounded in a proper spirit, is not only interesting, but it opens up useful material for future discussion. On the other hand, not the least important feature is the insight which the book affords the general reader of known physical facts and phenomena connected with the earth and planets.

A Manual of School Hygiene. By Prof. E. W. Hope, E. A. Browne, and Prof. C. S. Sherrington. New and Revised Edition. Pp. xii+311. (Cambridge University Press, 1913.) Price 4*s*. 6*d*.

THE first edition of this manual, which was reviewed in our issue for August 15, 1901 (vol. lxiv., p. 373), was reprinted on three occasions before the appearance of the book in its present form. Six chapters on physiology by Prof. Sherrington have here been added. They aim at emphasising the salient portions of the subject, and deal with the body considered as a mechanism, the blood and its circulation, respiration, food and digestion, the temperature of the body, and muscle and nerve.

Library Cataloguing. By J. Henry Quinn. Pp. viii+256. (London: Truslove and Hanson, Ltd., 1913.)

MR. QUINN'S book should prove of real service as a guide for young librarians to the various codes of cataloguing rules. His bright, helpful chapters should certainly convince the beginner in library work that the office of librarian is no sinecure; and the arrangement of his matter, and the subjects chosen for treatment, should enable information on practical cataloguing to be obtained with a minimum expenditure of trouble.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Energy in Planetary Motions.

IF a particle of mass m be brought from infinity to distance r by the action of a central attraction varying as the inverse square of the distance, the potential energy exhausted in the process is $m\mu/r$, where μ is the "intensity of the centre." If the particle has experiênced no resistance to its motion the kinetic energy is given by the equation

$$\tfrac{1}{2}mv^2 = m\frac{\mu}{r}.$$

But if the particle be made to move in a circle of radius r about the centre of force, the speed v is given by

$$v^2 = \frac{\mu}{r};$$

and the kinetic energy $\frac{1}{2}mv^2$ represents only half the potential energy exhausted. The other half must have been dissipated or disposed of in some way or other.

Similarly, if the particle be brought in from motion in a circle of radius r' about the centre to motion in the circle of radius r, so that potential energy of amount $m\mu(1/r-1/r')$ is exhausted, the kinetic energy has been increased by only $\frac{1}{2}m\mu(1/r-1/r')$, so that again only half of the potential energy exhausted is represented by the orbital motion, and the remainder has been expended in doing work against resistance of some sort. The central force has, in fact, done exactly twice as much work as that represented in the increase of the kinetic energy.

All this, of course, is perfectly elementary and well known, but it is nevertheless a curious dynamical fact that exactly half of the work done by the attraction must be expended in overcoming resistance.

I have not seen the corresponding theorem in elliptic motion anywhere explicitly stated. It is as follows:—*The time-average of the kinetic energy, taken for one revolution in the orbit, is half of the corresponding time-average of the potential energy exhausted in the passage from infinity to the distance* r. A similar theorem holds, of course, for the differences of energy concerned when the particle is transferred from one orbit to another about the same centre.

Let $2a$ be the length of the major axis of the elliptic orbit. The speed v at distance r from the centre is then given by

$$\tfrac{1}{2}v^2 = \mu\left(\frac{1}{r} - \frac{1}{2a}\right),$$

which, multiplied by m, is the equation of energy. The potential energy exhausted from infinity to distance r is again $m\mu/r$, and it can easily be shown that the time-average of the kinetic energy in the orbit is $m\mu/2a$.

Parenthetically, it may be remarked that this result is most easily and elegantly established by the following Newtonian process. If when r is the distance of the particle from the centre of force (one focus of the ellipse) r' be the distance from the other focus, and p, p' be the lengths of the perpendiculars from the foci on the line of motion at the instant, we have $r/r' = p/p'$, and, therefore, since $pp' = b^2$, where b is the length of the semi-minor axis, we have $r'/r = p'^2/b^2$. But the equation for v^2 can be written

$$v^2 = \frac{\mu}{a}\frac{2a-r}{r} = \frac{\mu}{a}\frac{r'}{r}.$$

Hence integrating for a period of revolution T we get

$$\int_0^T v^2dt = \int vds = \frac{1}{b}\sqrt{\frac{\mu}{a}}\int p'ds,$$

where ds is an element of the path, and the integrals with respect to s are taken once round the ellipse. Now, clearly $\int p'ds$ is twice the area of the ellipse—that is, $2\pi ab$. Thus

$$\tfrac{1}{2}m\int_0^T v^2dt = \pi m\sqrt{\mu a}.$$

The period T is $2\pi\sqrt{a^3/\mu}$, and so the mean kinetic energy is

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